

AN EVALUATION OF SHORLEAF PINE DECLINE  
AND MORTALITY ON THE STEARNS RANGER DISTRICT  
OF THE DANIEL BOONE NATIONAL FOREST

By

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The Stearns Ranger District of the Daniel Boone National Forest has a history of shortleaf pine (*Pinus echinata* Mill.) decline. The area mapped as Figure 1, located in southeastern Kentucky (McCreary and Whitley Counties), includes about 12,000 acres (approximately <sup>4,800</sup>~~30,000~~ hectares). This area has in the past supported hardwood/pine stands of 50-70% shortleaf pine. In 1962 a report (interoffice correspondence, R7--9/19/62--Shane and Freeman) was made which suggested that littleleaf disease was present on the site. Unfortunately the causal fungus, *Phytophthora cinnamomi* Rands, was not isolated at that time. In an informal investigation in 1972 W. H. Sites (FI & DM, Asheville, N.C.) again confirmed the symptoms but did not successfully isolate the causal fungus. Since that time much of the standing shortleaf has been condemned and removed.

Despite previous failures to isolate the fungus, Campbell, Gooding and Haais (1963) reported both McCreary and Whitley Counties as areas of known littleleaf disease. They further

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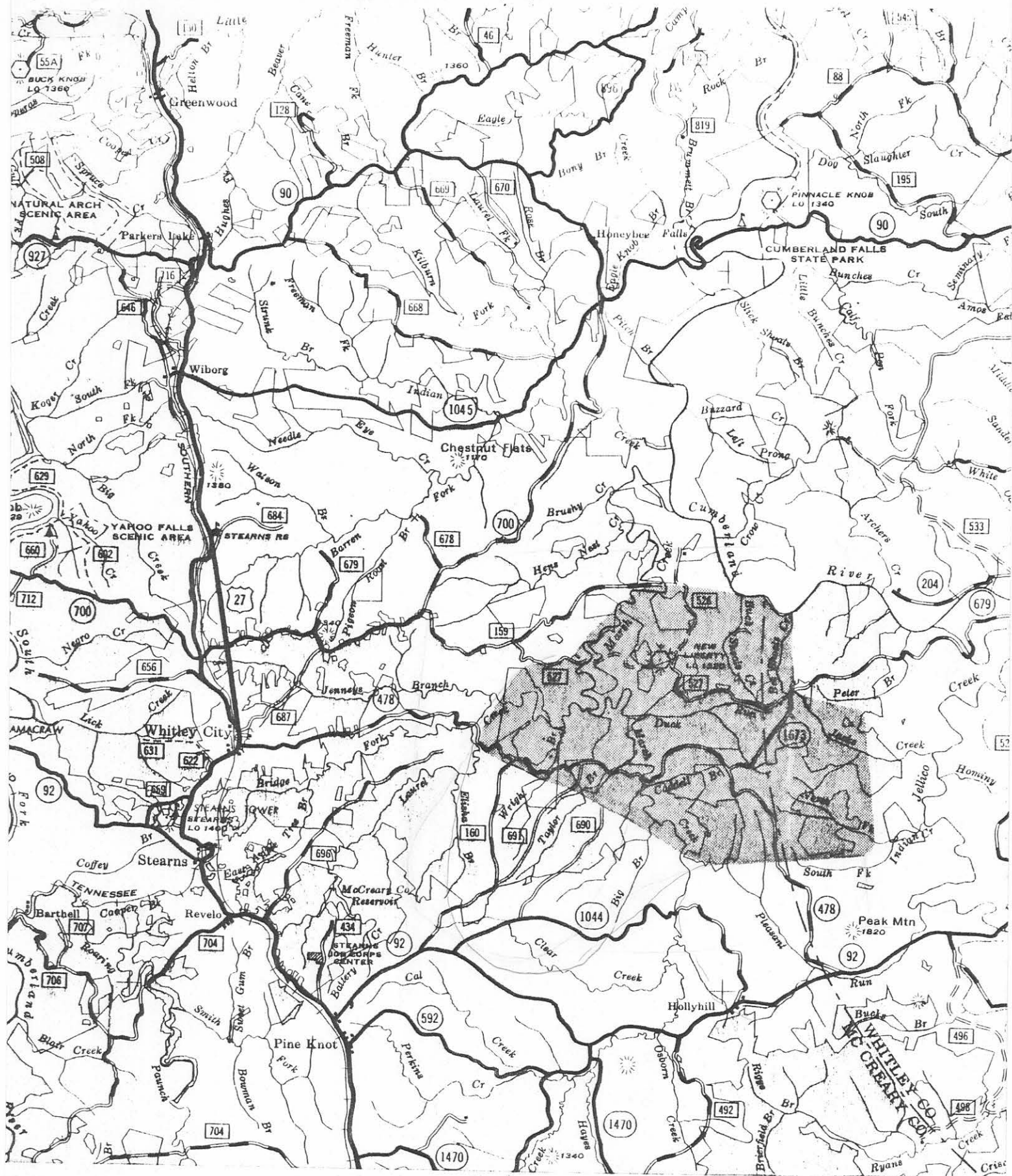


Figure 1. Map of the Stearns Ranger District showing location of the area of littleleaf diseased shortleaf pine. Scale 1:250,000.

state they did succeed "...during the course of the present study..." in their attempts to isolate the fungus from soil in these counties (1963, pg. 924).

The current investigation was undertaken in an attempt to clarify the cause of the shortleaf pine decline in this area prior to site regeneration. Goals were to determine the nutrient status of common soils in the area and to again attempt to isolate *P. cinnamomi* from the soils.

*P. cinnamomi* (Oomycetes, Peronosporales, Pythiaceae) is a fairly common soil inhabiting fungus. It is a weak parasite which, where edaphic factors are favorable, attacks and rots the feeder roots of both shortleaf and loblolly pines. Soil conditions generally associated with this disease include heavy and wet soils with poor aeration and low fertility (primarily nitrogen) (Campbell, Copeland & Hepting, 1954; Copeland & McAlpine, 1955; Hepting, 1949; and Zak, 1961). Nematodes and some species of *Pythium* (Pythiaceae) further enhance the effect of the disease on the host.

The most satisfactory method reported for isolating this fungus requires soil sampling, wetting these samples for 24-48 hours, placing the wet soil into apples for 4-8 days, isolating from suspect rot in the apple on some form of selective medium, and finally identifying the rot causing organism (Campbell, 1949). More recently a modification

of Kerr's medium has been recommended for direct fungal isolation from the soil (Hendrix & Kuhlman, 1965).

A detailed map of the sites investigated is presented as Figure 2. From the contour lines present it will be readily appreciated that the area in question is quite hilly. The shortleaf pine present is normally restricted to the upper slopes and ridges. It is precluded from the draws by the massive regeneration and faster growth of the indigenous hardwood population.

Residual soils of the area are DeKalb and Clymer where formed from acid sandstone. Wellston soils generally occur from parent materials of shale and siltstone. Seldom do these soils exhibit characteristics normally associated with littleleaf diseased areas.

Within the area of study, colluvial soils of Tate and Shelocta have been treated as potential littleleaf sites.

#### METHODS

##### (a) Biological Evaluation:

Soil samples were generated by collecting soil from around the base of a declining shortleaf pine or, where necessary, from the area of a stump identified as shortleaf pine. Soil from the ground level (duff removed) down to a depth of 6 inches was combined from 5 standard soil probe cores in the area of a



Figure 2. Map of affected area in Figure 1 showing the eight sampling locations. Scale 1:24,000.

single tree/stump. Thirty 5 core samples were taken from a total of eight sites. These sites are mapped in Figure 2. In Table 1 is recorded the number of samples taken and soil series found at each site.

These samples were slaked and brought into the lab for analysis. The apple technique was used (Campbell, 1949). Apples were incubated for five days and then analyzed. Suspect dry rot was plated on a selective antibiotic pythium medium.

Identification of cultures was made after three days of incubation at room temperature.

(b) Soils Evaluation:

Soils were examined at each site and classed as to soil type. Each major horizon was sampled and chemical analysis performed for all essential elements plus pH, exchangeable acidity, exchangeable aluminum and specific conductivity. Analyses were performed by the Northeast Forest Experiment Station at Berea, Kentucky.

## RESULTS AND DISCUSSION

Results of the isolation procedure are presented in Table 1. Nine of the 30 soil samples tested were determined to be positive for *P. cinnamomi*. Soil series in which the fungus was found include Clymer, Wellston and DeKalb.

| <u>Site #</u> | <u># Samples<br/>Taken/Positive</u> | <u>Soil Series</u> |
|---------------|-------------------------------------|--------------------|
| 1             | 4/0                                 | Clymer             |
| 2             | 2/2                                 | Clymer             |
| 3             | 6/5                                 | Wellston           |
| 4             | 2/0                                 | Tate               |
| 5             | 6/0                                 | DeKalb             |
| 6             | 2/1                                 | Clymer             |
| 7             | 3/1                                 | DeKalb             |
| 8             | 5/0                                 | ?Muse-Trappist     |
| Total         | 30/9                                |                    |

Table 1. Breakdown of soil samples by number taken/number with *P. cinnamomi* present and by soil series. Location of sites can be determined from Figure 1.

Table 2 shows soil laboratory data for each essential element. Table 3 presents the results from the chemical indicator tests. As pointed out earlier the physical characteristics of the soils of the area are not those normally associated with littleleaf disease. However, Copeland and McAlpine (1955) showed that areas affected by littleleaf were generally lower in soil nitrogen, as are all sites tested, than unaffected sites.

Using Bray's lab method, phosphorus levels of 0-3 ppm are very low; 3-7, low; 7-20, medium and over 20, high (1 Bray - 1.42 ppm HCl - H<sub>2</sub>SO<sub>4</sub>).

According to the 1974 CRIFF (Anon., 1974) report where acid extracted phosphorus is in the range of 2.5-5 ppm. as on this site, an additional 20-40 pounds of phosphorus is recommended to optimize growth. While this study was conducted for slash pine, the indication is that phosphorus, as well as nitrogen, is currently at an unacceptably low level.

Examination of the micronutrients indicate that boron and molybdenum could also be limiting since the concentrations are below the detection limits of the laboratory.

Combining the soils information with the demonstrated presence of *P. cinnamomi*, and symptoms being expressed by the trees (Fig. 3) confirms the presence of littleleaf disease of shortleaf pine in the study area. This bears out the conclusion of Campbell, et. al. (1963).

| Site | Depth | N*  | P** | K     | Ca <sub>1</sub> | SO <sub>4</sub> | Mg   | Fe   | Mn   | B   | Zn  | Cu   | Mo  | Cl  | $\frac{P}{HCl-H_2SO_4}$<br>eq. |
|------|-------|-----|-----|-------|-----------------|-----------------|------|------|------|-----|-----|------|-----|-----|--------------------------------|
| 1    | 0-4   | .21 | 2.7 | 43.4  | 97.5            | 41              | 15.8 | 43.2 | 11.9 | < 1 | 3.2 | .65  | <.1 | .3  | 3.8                            |
|      | 20-40 | .05 | .5  | 34.6  | 41.2            | 53              | 16.3 | 19.5 | .9   | < 1 | 2.6 | .69  | <.1 | .5  |                                |
| 2    | 0-8   | .05 | 3.6 | 96.8  | 64.9            | 94              | 34.9 | 115  | 61.6 | < 1 | 2.4 | 1.33 | <.1 | 1.9 | 5.1                            |
|      | 20-35 | .04 | 1.0 | 34    | 46.2            | 41              | 52.4 | 18.1 | .8   | < 1 | 2.6 | .63  | <.1 | .3  |                                |
| 3    | 0-7   | .29 | 3.1 | 122.1 | 880             | 53              | 73.1 | 71.4 | 88.5 | < 1 | 5.1 | 1.3  | <.1 | 2.2 | 4.4                            |
|      | 8-24  | .01 | .3  | 32.9  | 122             | 198             | 2.0  | 15.7 | 1.5  | < 1 | 2.0 | .97  | <.1 | 0   |                                |
|      | 24-40 | .04 | .5  | 36.7  | 13              | 41              | 89.4 | 14.4 | .8   | < 1 | 3.5 | .86  | <.1 | 0.5 |                                |
| 5    | 0-5   | .26 | 2.9 | 41.1  | 203             | 53              | 20.2 | 80.0 | 19.8 | < 1 | 2.4 | 1.11 | <.1 | 1.0 | 4.1                            |
|      | 20-30 | .05 | 1.2 | 26.7  | 83.5            | 53              | 22.1 | 22.8 | 3.9  | < 1 | 2.2 | .81  | <.1 | .5  |                                |
| 6    | 0-6   | .13 | 3.2 | 21    | 145             | 41              | 13.9 | 38.9 | 6.9  | < 1 | 4.7 | .72  | <.1 | 1.7 | 4.5                            |
|      | 14-24 | .09 | .9  | 60    | 92.4            | 70              | 82.8 | 18.7 | 1.6  | < 1 | 2.4 | .53  | <.1 | 1.6 |                                |
| 7    | 0-4   | .42 | 2.9 | 40.1  | 61.6            | 41              | 9.3  | 51.9 | 9.8  | < 1 | 2.7 | .60  | <.1 | .8  | 4.1                            |
|      | 15-25 | .04 | .3  | 70.6  | 101             | 70              | 56.3 | 22.1 | .7   | < 1 | 5.7 | .63  | <.1 | 1.3 |                                |
| 8    | 0-4   | .2  | 2.9 | 45.6  | 21.1            | 41              | 6.6  | 123  | .9   | < 1 | 3.3 | 1.02 | <.1 | 1.8 | 4.1                            |
|      | 15-25 | .04 | .9  | 65.7  | 22.6            | 99              | 13.7 | 19.7 | .8   | < 1 | 3.0 | .6   | <.1 | 5.7 |                                |

\* Interpretation of nitrogen analysis is difficult from laboratory results. The results presented are for later reference only and were achieved by passing water through the soil and measuring the concentration of NO<sub>2</sub> + NO<sub>3</sub> in the extract solution.

\*\* Bray Method.

Table 2. Results of laboratory analysis for essential element content (in PPM) of soils from seven sites on the Stearns Ranger District (see Fig. 2) of the Daniel Boone National Forest. (Analysis was not made for soils at site 4, Tate series).

| Site | Depth | pH  | Sp. Cond. | Exch. Acid | Exch. Al. |
|------|-------|-----|-----------|------------|-----------|
| 1    | 0-4   | 4.3 | .05       | .4         | .0        |
|      | 20-40 | 4.2 | .02       | 1.6        | .4        |
| 2    | 0-8   | 4.2 | .08       | .8         | .1        |
|      | 20-35 | 4.5 | .02       | 1.6        | .2        |
| 3    | 0-7   | 5.4 | .07       | .4         | .0        |
|      | 8-24  | 4.5 | .01       | 3.2        | 3.1       |
|      | 24-40 | 4.6 | .01       | 6.0        | 4.9       |
| 5    | 0-5   | 5.1 | .04       | .4         | .0        |
|      | 20-30 | 4.4 | .02       | .8         | .0        |
| 6    | 0-6   | 4.7 | .03       | .4         | .0        |
|      | 14-24 | 4.5 | .02       | 3.6        | 3.5       |
| 7    | 0-4   | 4.6 | .03       | .2         | .0        |
|      | 15-25 | 4.4 | .02       | 3.6        | 2.8       |
| 8    | 0-4   | 4.0 | .04       | .8         | .2        |
|      | 15-25 | 4.3 | .02       | .8         | .0        |

Table 3. Results of tests of chemical indicators for seven soils sampled on the Stearns Ranger District of the Daniel Boone National Forest. (Analysis was not made for the eighth sample, Tate series).



A



B



C

Figure 3. Expression of littleleaf symptoms and mortality on three of the tested sites. (A = Site 1, B = Sites 2 and C = Site 6).

Loblolly pine has been repeatedly suggested as an alternative to shortleaf (Bryan, 1966; Campbell, et. al., 1953; Campbell & Copeland, 1954; and Hepting, 1949) in areas of high littleleaf hazard. There are two serious cautions which must be evaluated where loblolly is being considered as a shortleaf alternative:

First, loblolly is not native to the area being considered. Any attempt to introduce this species to the Stearns Ranger District will probably encounter serious abiotic (frost damage, soils types, ice breakage, cool summer, day length, etc.) and biotic (southern pine beetle, annosus root rot, littleleaf, etc.) problems.

Second, loblolly pine is susceptible to littleleaf disease! Within its normal growing range it is far less susceptible than shortleaf. However, the introduction of a non-indigenous host species (loblolly) into an area already colonized by *P. cinnamomi* could lead to severe problems in the future.

Application of inorganic fertilizers high in nitrogen, at minimally, 250 lbs. nitrogen per acre (1 ton per acre of 5-10-5) plus 750 lbs. ammonium sulfate per acres, has been shown to be effective in preventing littleleaf among healthy trees and has induced recovery in trees showing early disease symptoms (Campbell, Copeland & Hepting, 1953). With a fertilization program, the Southern Forest Experiment

Station in Suwannee, Tennessee has (~~been~~) shown these same soils capable of producing high quality hardwood species. Haines, et. al. (1976) showed that fertilization of advanced stands of loblolly pine could be accomplished for \$35-69 per additional MBF/A.

While a full scale site rehabilitation program, including subsoiling and fertilization, seems to be indicated to return this soil to an acceptable level of productivity, a detailed economic analysis for cost/benefit would be needed to properly evaluate this choice.

#### RECOMMENDATIONS

Given the knowledge that littleleaf disease is present on shortleaf pine in the sampled area, only two alternatives are sound from the standpoint of pathology:

- (1) Establish vigorous-healthy shortleaf pine stands by site preparation and fertilization as mentioned in the discussion and proposed by Campbell, et. al. (1954). Anything done to encourage an understory of leguminous trees (e.g. *Robinias*) would aid in site rehabilitation through nitrogen fixation.
- (2) Allow the area to regenerate in its natural hardwood mixture. Some sites were clear-cut for littleleaf disease which were not shortleaf sites. These sites should be allowed to

regenerate in its natural hardwoods. Again, encourage the growth of leguminous species.

It is recommended that an administrative study using existing shortleaf pine stands be established. Through a judicious program of thinning and fertilization it is believed that the threat of littleleaf can be eliminated from the site. The fertilization program may be expected to return an interest of over 10% on the investment in growth alone.

Extensive use of non-native species is not recommended. For the purpose of performance evaluation, small test outplantings of loblolly pine might be made. However, there are too many uninvestigated environmental influences in this area to consider outplanting any non-native species in southeastern Kentucky as a viable management alternative at this time.

One further performance evaluation which might be considered is the pitch x loblolly pine hybrid (see enclosure). As with loblolly pine this is suggested as a test only, large scale outplanting should be avoided at this time.

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Experiment Station, Berea, Kentucky.

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REPORT ON  
COOPERATIVE PITCH X LOBLOLLY HYBRID PROJECT

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Summerville, S. C.

March 31, 1976

Background:

1. In 1963 Westvaco entered into a cooperative agreement with the U. S. Forest Service, Northeastern Forest Experiment Station, to breed and test the pitch x loblolly hybrid.

The main purpose was to develop a pine hybrid having the growth and form of loblolly with the cold resistance and site adaptability of pitch pine for use on lands in West Virginia, western Maryland and Pennsylvania that supply wood to Company mills in that geographical area. The U. S. Forest Service wished to develop the hybrid for regeneration of lands throughout the Northeast.

2. The Forest Service under the direction of Silas Little at New Lisbon, N. J. searched for acceptable pitch pine from Maine to Pennsylvania and for acceptable loblolly in Maryland and Delaware. Westvaco research also selected several pitch pine in Virginia, West Virginia, Pennsylvania and New York. The pitch pine in Virginia and West Virginia were graded by the N. C. State Forest Tree Improvement Cooperative. In cooperation with state forest service personnel, 32 loblolly and 32 pitch mother trees were selected.
3. Scions from the parent trees were sent to the Westvaco Charlottesville Research Center for grafting spring 1964. During the fall of 1964, 900 grafted pitch and loblolly were sent to Si Little at New Lisbon, N. J. for planting into a breeding orchard of 5 acres contributed by the N. J. State Forest Service.
4. Four years later in 1968 Si Little started making controlled crosses of loblolly pollen onto pitch flowers. He has made annual crosses through 1973 using pollen from Maryland selections as well as pollen from N. C. State graded loblolly located in Maryland, Virginia and South Carolina.
5. Westvaco has obtained the seeds from Si which we clean, count, store, stratify and sow in the Maryland State Nursery. We always lift, grade, count and package the seedlings for planting.

6. Westvaco established the first progeny tests in 1971 at Alderson, West Virginia and Livingston, Kentucky. The 1972 test is at Duo, West Virginia; the 1973 and 1974 tests are at Parkersburg, West Virginia.
7. During the past 5 years, 19 test plantings have been made by Westvaco, Glatfelter, VPI and for state forestry organizations in 8 states - Kentucky, Virginia, West Virginia, Maryland, Pennsylvania, New Jersey, New York and Massachusetts. Several plantings are scheduled for spring 1976; New Hampshire will be added to the list.
8. The last cone crop was harvested from the New Jersey orchard October 1975. Many of these crosses are for Westvaco testing because most of the pollen came from several graded loblolly in Virginia and South Carolina.

#### Results:

1. Results are good at all plantings. Specifically, Westvaco plantings have excellent survival of 90% up, except at Parkersburg where pales reduced survival to 75%. Growth of the hybrids are always better than pitch checks, while several hybrids have grown taller and larger than the loblolly checks. See attached graphs.
2. The form of the hybrid is nearly always superior to the crooked, inferior form of the pitch check.
3. Extra hybrid stock graded out of stock used in the 1972 plantings was salvaged by the State of Maryland and planted on an old strip near Frostburg, Maryland. Many stems (source unknown) grew 9 feet tall in 4 years, while spruce, red, white and Scots pine are only 1½ to 2 feet tall. The strip is barren of vegetation and has not been fertilized.

Based on this planting as well as plantings in the northeast corner of Maryland, the Maryland Forest Service wants to mass produce the hybrid.

4. Plantings in the pine barrens of New Jersey are equally impressive, e.g., a New York pitch x loblolly 7-56 has reached a maximum 7.3 feet in 3 years.

The New Jersey State Forester expressed to me a desire to mass produce the hybrid.

5. The Ohio Division of Forestry and Reclamation announced plans to establish a seed orchard using Korean pitch x loblolly stock. Si Little asked them to consider our crosses which outperform the Korean hybrids.

6. Hiwassee Land Company has reviewed the project and decided to start searching for pitch selections. Hiwassee is interested in the hybrid for planting on the Cumberland Plateau at elevations of 2,000 - 2,500 feet.

Present and Future Plans:

After discussions with Dr. Bruce Zobel, Dr. S. K. Hyun (Korea) and Dr. Carlyle Franklin, Westvaco plans to proceed as follows with the project:

1. Spring 1976, mass pollination of best pitch with best loblolly;
  - a) Si Little to perform mass pollination in New Jersey seed orchard using back pack mist blower and/or wand pollinator.
  - b) Six clone loblolly pollen mix to be used consisting of 15A, 22 and 23 which are mother trees located in Maryland; 4-32 Chesapeake Corp. Virginia seed orchard; 11-9 and 7-56 Westvaco S. C. seed orchard.
2. Spring 1976, plant pitch root stock in Westvaco Summerville, South Carolina seed orchard complex for grafting in 1977.
3. 1976, select additional pitch from West Virginia area.
4. Spring 1977, repeat mass pollination as above.
5. Spring 1977, establish by grafting in the Summerville, South Carolina area a breeding orchard consisting of a minimum of 20 clones from Westvaco selections plus selections of Georgia Kraft and the North Carolina Forest Service.
6. Spring 1978 and continuing mass pollination of existing pitch material according to seed needs.
7. Spring 1980 (Estimate) - Mass and controlled pollination of Westvaco Summerville pitch seed orchard.
8. Outplant progeny including the best of Dr. S. K. Hyun's hybrids to broaden genetic base.
9. After four growing seasons select best hybrids.
10. Establish seed orchard in Summerville area by grafting 30+ best selections of pitch x loblolly hybrid.

HEIGHT IN FEET

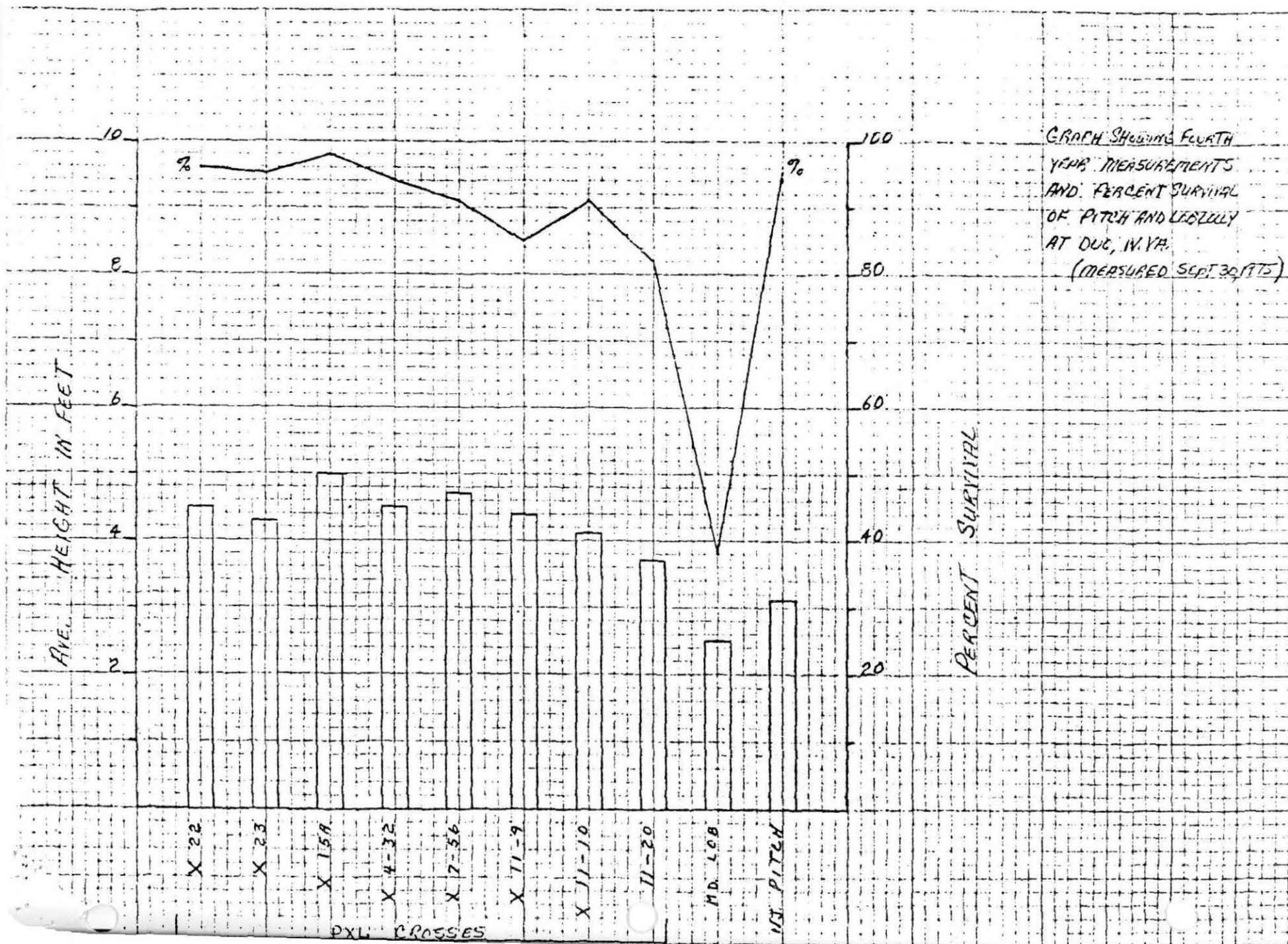
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GRAPH SHOWING EXTRE  
SPREAD AND AVERAGE  
HEIGHT, PITCH X LOE  
DUO, WEST VIRGINIA  
FOURTH YEAR MEASUREM  
SEPT 30, 1975

HIGH  
PLANTATION AVERAGE  
AVE.  
LOE

77X4-92  
62X7-56  
77X22  
62X11-9  
70X23  
71X15A  
60X7-56  
75X2B  
67X69  
59X11-0  
59X7-56  
78X23  
54X7-56  
62X11-0  
58X11-85  
78X9  
71X23  
72X67  
70X22  
62X57  
59X11-0  
58X11-0  
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62X11-20  
58X11-56  
67X23  
25X11-7  
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71X22  
61X11-85  
25X11-57  
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58X11-20  
54X11-20  
64X11-49  
65X11-10  
65X11-59  
63X23  
NOT PITCH  
NO LOE

TH



For any additional information, Contact

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